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IMMUNITY OF VIKING A NORWEGIAN RED CURRANT TO CRONARTIUM RIBICOLA AND C. OCCIDENTALE UNDER GREENHOUSE CONDITIONS

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IMMUNITY OF VIKING, A NORWEGIAN RED CURRANT, TO CRONARTIUM RIBICOLA AND C. OCCIDENTALE UNDER GREENHOUSE CONDITIONS[1]

By GLENN GARDNER HAHN,[2] *Pathologist, Division of Forest Pathology, Bureau of Plant Industry*

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INTRODUCTION

Extensive investigation in the United States and Europe has been directed toward the estimates of susceptibility of currants and gooseberries (*Ribes* spp.) to white pine blister rust (*Cronartium ribicola* Fischer). Field and greenhouse inoculation tests have demonstrated that *Ribes* species are generally susceptible to blister rust. No species or variety has been unquestionably proved to be immune (*2*).[3] This particularly applies to the group of red and white currant varieties of confused parentage. Among a large number of varieties of common garden currant tested, only a very few (*5*, *6*) have been found to be resistant.

[1] Cooperative investigations between the Bureau of Plant Industry, U.S. Department of Agriculture, and the Osborn Botanical Laboratory, Yale University.

[2] Throughout this investigation in the United States, the writer received assistance from various workers in the U.S. Department of Agriculture, which he here gratefully acknowledges: To Knowles A. Ryerson, formerly of the Division of Plant Exploration and Introduction, now of the Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, who arranged for the introduction of plants and cuttings of the Viking currant from Norway, and Peter Bisset, of the former Plant Quarantine and Control Administration, who provided for their care on their arrival in this country; to Mae Spradling, Ruby J. Acree, and R. B. Clapper, of the Division of Forest Pathology, Bureau of Plant Industry, who assisted the writer at various times in notetaking and who otherwise aided him in his experiments; to C. O. Erlanson, of the Division of Plant Exploration and Introduction, for translations of Scandinavian horticultural literature; to E. C. Filler and the other members of the Division of Blister Rust Control, for their cooperation in procuring fresh white pine blister rust material for inoculation purposes; to E. Wright of the Division of Forest Pathology, for fresh collections of piñon blister rust; and to the late Robert MacLennan, formerly of the pathological greenhouses, Bureau of Plant Industry, under whose supervision plant cuttings from Norway were propagated in the United States.

[3] Italic numbers in parentheses refer to Literature Cited, p. 16.

In 1927 the writer (*4*) observed a Norwegian variety of red currant which Norwegian pathologists regarded as highly resistant to white pine blister rust under field conditions. A preliminary investigation (*4*), conducted at the Royal Botanic Garden, Edinburgh, Scotland, in 1929, indicated that under conditions of artificial greenhouse experimentation the currant was immune to Scottish strains of blister rust. The Norwegian variety has been subsequently inoculated with American strains in the United States over a period of 3 years, 1930–32, and found to be immune. The results of American greenhouse tests confirm those obtained in Scotland and corroborate the opinion of Scandinavian pathologists and horticulturists, who have observed that the red currant from Norway, even when growing in direct association with diseased five-needle pines, is not infected with Norwegian strains of white pine blister rust. The immune currant, which is a hybrid form of *Ribes petraeum* Wulf., is herein described under the new varietal name Viking.

HISTORY OF THE IMMUNE CURRANT

Only meager information has been obtained concerning the antecedents of the immune red Norwegian currant, a preliminary description of which is given later.[4]

Thayer has indicated that the synonomy of the Red Dutch is very much confused. As forms of the Red Dutch have been propagated for 200 years or more, many modifications are to be expected In his treatise on the red and white currants he makes the following statement (*8*, *p. 345*) concerning the Red Dutch variety:

> The name Red Dutch first appears in print in 1670 or 1690. It is not to be supposed that the Red Dutch as grown today is the same as the Red Dutch of two centuries ago. In fact, the Red Dutch as grown in America and the Red Dutch (Hollandische Rote and Rouge de Holland) of continental Europe belong to different species, while we have received plants from England under the name Red Dutch belonging to still a third species.

The Norwegian currant reported in this circular is not the same as the Red Dutch currant grown in North America, which under conditions of artificial testing has been found to be susceptible to white pine blister rust (*4*, *5*, *6*). Although the two originally possessed the same varietal name, they are entirely different. The Viking currant from Norway belongs to the *Ribes petraeum* group, whereas the American Red Dutch belongs to the group in which the physical characteristics of *R. sativum* (Reichenb.) Syme (*R. vulgare* Auct., not Lam.) predominate.

According to Stedje, the red Norwegian currant is not identical with Holland (syn., Long Bunch Holland), another *Ribes petraeum* hybrid of continental origin (*8*, *p. 339*), which was possibly introduced into the United States about 1855. Stedje regards the immune

[4] Whatever knowledge of the Viking variety the writer has been able to gather has come largely through the kindness of P. Stedje, horticulturist, Norway State Fruit Experiment Station, Hermansverk, Sogn, Norway, who in a recent written communication informed the writer that a description of the Norwegian red currant does not occur in Norwegian pomological literature. It is the opinion of Stedje that the variety grown in Norway under the name Rød Hollandsk Druerips, i.e., Red Dutch grape currant (Norsk Havetidende 16: 137, 1900; 27: 257, 1911), is very old and probably is to be considered one of the many forms of the parent stock of the Red Dutch currant cultivated in Europe since the end of the seventeenth century (*8*). How or where the Norwegian variety originated can only be conjectured. It is regarded by horticulturists as the best currant grown at present in Norway, where it is common and widespread.

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A, Leaf of American Red Dutch currant belonging to the *Ribes sativum* and hybrids group; *B*, fruit of Viking currant collected at Bar Harbor, Maine, July 27, 1933; *C*, leaf of Viking currant belonging to the *Ribes petraeum* and hybrids group. Fruit about natural size; leaves about three-fourths natural size. Paintings by R. C. Steadman. Leaves photographed by L. A. Guernsey.

variety from Norway as very similar to the *R. petraeum* hybrids Prince Albert (*8, p. 344*) and Rivers Late Red, which are regarded by Thayer as identical. The Prince Albert, which is also a continental variety, Thayer (*8*) considers distinct from Holland.

In Denmark a red currant grown under the name "Røde Hollandske Ribs" (J. A. Dybdahl, Jordbaer-og vore Vigtigste Frugtbusk-arter, 1879) is, according to Stedje, not identical with the Norwegian Rød Hollandsk Druerips. Inasmuch as the synonomy of the Red Dutch is so confused, it would seem proper at this time to designate the immune currant by a name which would distinguish it from all other red currants, including those of distinct botanical origin, bearing the name "Red Dutch." The name "Viking"[5] has been chosen to designate the old Norwegian variety, which, according to Thayer,[6] probably has not been introduced heretofore into this country.

DESCRIPTION[7] OF THE IMMUNE CURRANT

Viking (a *Ribes petraeum* hybrid).

Synonym.—Norwegian "Rød Hollandsk Druerips"; not the Danish "Røde Hollandske Ribs."

The introduced variety belongs to the group derived, in part at least, from the species *Ribes petraeum*, which is the latest to flower and to ripen its fruit. The bushes of this group are very vigorous and upright and more healthy and resistant to the currant worm than others. The fruit of the Viking is of medium size, not so dark as that of many sorts, but very attractive. Its late, long season should make it especially valuable in northern regions.

TECHNICAL DESCRIPTION

Bush.—Vigorous, rather large, upright, productive, healthy; young shoots stout, bright red during early summer, with light grayish-brown bark; the epidermis on young shoots becomes loosened and hangs commonly in shreds.

Leaves.—Starting late and dropping late; leaf buds large, long, pointed; leaves dark green, glossy, rugose, cupped, truncate at base, longer than broad, with three long-pointed lobes, often unequal in size, the right being frequently the larger (pl. 1, *C*); pubescent below, with sharp, deep, doubly serrate to crenate margins; petiole long, stout, tinged with red, and with a slight pubescence, holding the foliage stiffly upright.

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[5] In a recent communication, Stedje wrote as follows: "As there are many varieties of Red Dutch currant which are not identical with our strains, I should be pleased if you in your publications would call our red currant Red Norwegian." The writer would be pleased indeed to comply with this request but for the fact that the names Norwegian and Norway already appear in horticultural literature. Thayer (*8, p. 357*) lists the Norwegian variety as introduced from Norway into Scotland in 1880. This variety may or may not be the same as that investigated by the writer. In 1914, a Lake State nursery listed in their catalog a variety called Norway, also of Norwegian origin. This latter variety, probably not a *Ribes petraeum* hybrid, was subsequently tested by Spaulding (*6, p. 21*) and the writer (*5, p. 111*) and found to be susceptible to white pine blister rust. It would seem best, therefore, not to designate the immune currant by the name suggested by Stedje. The name Viking has been chosen because of its Scandinavian connotation and because the writer desired to use a designation expressive of the vigorous growth of the variety, in compliment to the country in which he recently received many courtesies and generous hospitality.

[6] Written communication.

[7] For the data upon which the description of the currant is based, the writer is indebted to P. Stedje and to G. M. Darrow, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, who recently made notes on the Viking currant where it is introduced and growing in the currant collection of the New York Agricultural Experiment Station, Geneva, N. Y.

Blossom racemes.—Long, with stems of variable length; densely flowered with 12 to 20 (average 17) pitcher- or bell-shaped flowers without a rim and with large petals and sepals, brownish above, light red or pink beneath.

Fruit.—Ripens and hangs on very late; clusters long, well-filled, tapering, rather loose (fig. 1); cluster stems long; berries of medium size, globose to globose-oblate, light, bright red (pl. 1, *B*); skin thin, smooth, tough, translucent; flesh juicy, sprightly subacid, highly flavored; quality good.

Because of their acidity the berries of Viking are especially suited for juice making. As a late variety for jelly making it holds much promise. It is a heavy bearer. According to Stedje the foliage is resistant to insects and diseases, but the writer's experience with it has been confined to white pine blister rust to which it is apparently immune.

The variety is hardy throughout the fruit-growing sections of Norway. It has no particular requirements and does well in nearly all kinds of soil. As seedlings of all clonal varieties of plants vary considerably in many respects from the parent, this rust-immune variety should be perpetuated exclusively by asexual propagation.

VARIETAL CHARACTERS DIFFERENTIATING THE VIKING FROM OTHER CURRANTS

According to the monographs by Berger (*1*) and Thayer (*8*), the cultivated red currants belong to three species, namely, *Ribes sativum*, *R. rubrum* L., and *R. petraeum*. The flowers of *R. sativum* and *R. rubrum* differ markedly from those of *R. petraeum* in having a shallow cup with ciliate sepals, whereas flowers of *R. petraeum*, to which species the Viking currant seems to belong, are pitcher- or bell-shaped without a rim and with large petals and sepals. *R. petraeum* is a native of the high mountains of Europe and north Africa and of most of Siberia. The bushes have stiff, erect shoots, start late in the spring, hold their foliage late in autumn, and are resistant to the currant worm. The shoots of the Viking[8] are very stout and erect and have foliage characteristic of *R. petraeum*. The bushes can be distinguished from the *R. sativum* and *R. rubrum* varieties by their very erect habit and stout shoots, and by their glossy, very dark green, deeply and sharply serrate, cupped leaves, with elongated lobes (pl. 1, *A* and *C*).

Darrow's notes on the leaf character of the various currant varieties[9] are as follows:

RIBES SATIVUM; R. SATIVUM VAR. MACROCARPUM; R. SATIVUM AND HYBRIDS GROUP

R. sativum.—Rather dull, medium green, rounded serrate, slightly cupped, very broad leaves with less elongated lobes.

RED CURRANT VARIETIES

Cherry.—Dull, medium green, uncupped or slightly cupped, shallowly round, serrate, broad leaves with shallow lobes.

Chautauqua.—Slightly glossy, dark green, very shallowly serrate, uncupped leaves, very broad with medium lobes.

Comet A.—Dull, dark green, coarsely rounded, serrate, very broad, uncupped leaves with shallow lobes.

Comet B.—Slightly glossy, dark green, very coarsely rounded, serrate, somewhat cupped, very broad leaves, with medium lobes.

Diploma.—Dull, medium serrate, uncupped, very broad, large leaves with very shallow lobes.

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[8] Observations made by Darrow, July 17 to 19, 1933. At that time he also observed leaf characters of the red and white currant varieties of the three *Ribes* species growing in the Geneva, N.Y., collection.

[9] The varietal names are those used in the collection at the New York State Experiment Station at Geneva, N.Y.

Everybody.—Dull, dark green, coarsely round, serrate, cupped, broad leaves with shallow lobes.

Fay.—Dull, dark green, round, shallow serrate, slightly cupped, very broad leaves with shallow lobes.

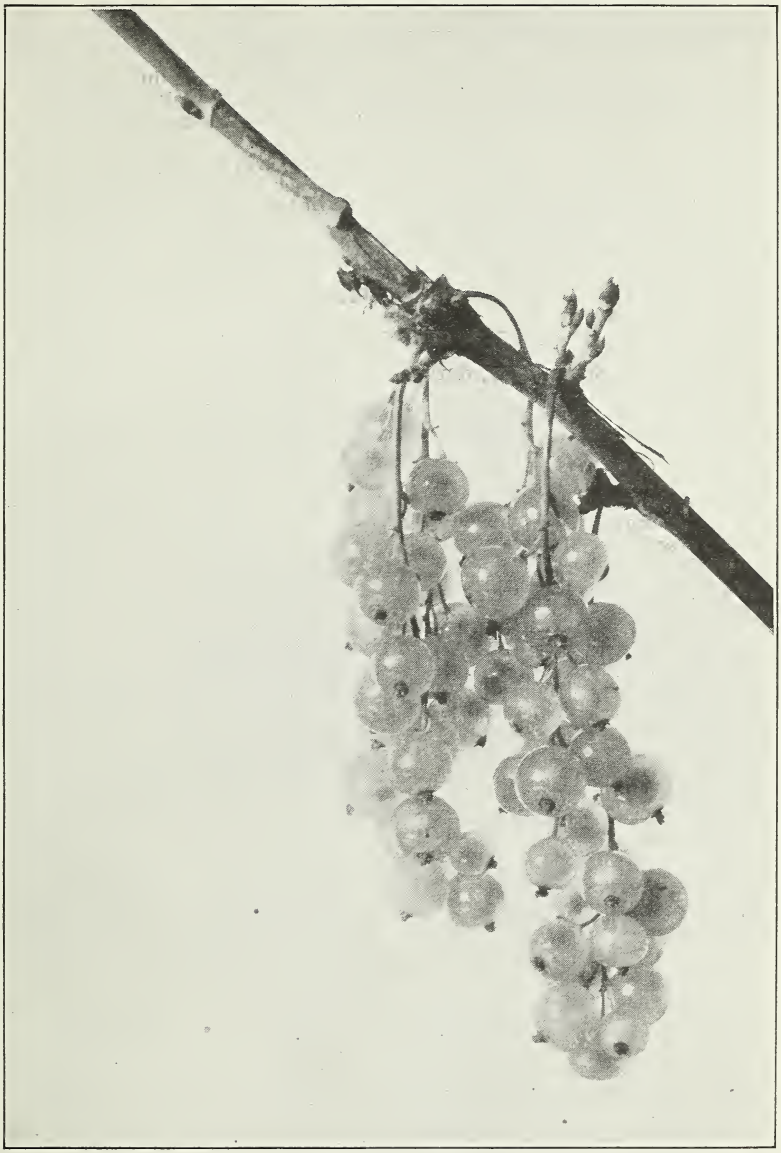

FIGURE 1.—Clusters of Viking currant showing length and attachment to fruit spurs. Natural size.

Filler.—Slightly glossy, coarsely round serrate, uncupped, very broad leaves with shallow lobes.

Imperial Red.—Dull green, coarsely and shallowly round serrate, broad leaves with shallow lobes.

Knight Sweet Red.—Slightly glossy, yellow-green, slightly cupped, round serrate, broad leaves with shallow lobes.

La Fertile (Red Dutch?).—Slightly glossy, slightly cupped, coarsely rounded serrate. very broad leaves, with shallow lobes.

La Hative.—Dull, yellow-green, uncupped, less serrate but rather deeply serrate, very broad leaves with long lobes.

Laxton Perfection.—Just like American Perfection.

Perfection.—Young leaves glossy, dark green; old leaves dull, yellow-green, shallow, round, serrate, uncupped, very broad with very shallow lobes.

Red Cross.—Dull, dark green, round serrate, very broad, uncupped leaves with medium lobes.

American Red Dutch.—Slightly glossy, rather dark, slightly cupped, shallow to rounded serrate, very broad leaves with shallow lobes (pl. 1, *A*).

Rosa Holland.—Dull, dark, finely and shallowly serrate, broad, uncupped to slightly cupped leaves with shallow lobes.

Versailles.—Dull, dark to yellow-green, uncupped, simply serrate, broad, rather deep lobes.

Wilder.—Slightly glossy, dark green, cupped, broad, medium serrate leaves with shallow lobes.

WHITE CURRANT VARIETIES

Bar le Duc.—Slightly glossy, dark green, deeply serrate, cupped, very broad leaves.

White Dutch.—Slightly glossy, dark green, cupped, medium rounded, serrate, broad leaves with medium lobes.

White Imperial.—Slightly glossy, uncupped, shallow, sharply serrate, broad leaves with shallow lobes.

White Transparent.—Dull, yellow-green, round, shallow, serrate, slightly cupped, broad leaves with shallow lobes.

White Versailles.—Slightly glossy, yellow-green, rather finely to coarsely serrate, slightly cupped, very broad leaves with shallow lobes.

White Grape.—Dull, dark green, coarsely rounded serrate, very broad, large uncupped leaves with shallow lobes.

RIBES RUBRUM AND HYBRIDS GROUP

Ribes rubrum.—Rather dull, medium green, finely serrate, slightly cupped, broad leaves with less elongated lobes.

R. rubrum (*R. rubrum* Schlecht).—Dull, dark green, cupped, broad, sharply serrate, broad, pubescent, red-veined leaves with shallow lobes.

Victoria.—Dull green, very broad, uncupped leaves, not sharply toothed and less elongated lobes.

Red Defiance.—Dull, dark green, finely serrate, broad, slightly cupped leaves with shallow lobes.

Scotch (syn.—London Market).—Dull to somewhat glossy dark green, cupped, finely doubly serrate, very broad leaves with 3 to 5 rather shallow lobes.

Wilson Long Bunch.—Slightly glossy to dull, sharply and coarsely serrate to very broad leaves with shallow lobes.

RIBES PETRAEUM AND HYBRIDS GROUP

Ribes petraeum.—Less glossy, dark green, sharply serrate, cupped, rather narrow leaves with less elongated lobes.

R. petraeum (*petrami*).—Less glossy, dark green, less sharply serrate, rather narrow leaves with less elongated lobes.

R. petraeum atropurpureum.—Dull, dark green, uncupped, not sharply serrate, broad leaves with very shallow lobes.

La Constante.—Glossy, dark green, cupped, sharply serrate, very broad leaves with less elongated lobes, the middle one not very long and the petioles much shorter.

Prince Albert.—Glossy, dark green, coarsely and rather deeply serrate, slightly cupped, broad leaves with rather long lobes; tallest bushes.

Among the foregoing varieties Darrow saw none that showed leaves so sharply and deeply toothed, dark, glossy, cupped, less broad than long, with such elongated lobes, as those produced by the Viking currant. In a comparison of 26 varieties and species it had

leaves of the greatest relative length of any, its leaves being 17 percent longer than broad, whereas leaves of Wilder were 19 percent shorter than broad and those of Perfection 11 percent shorter. How much change in leaf characters will occur as the introduced plants get older is uncertain, but inspection of the planting at Geneva suggests these as good varietal marks.

INOCULATION EXPERIMENTS WITH WHITE PINE BLISTER RUST

Young plants of the Viking currant from Norway, propagated from cuttings at the Royal Botanic Garden, Edinburgh, Scotland, and later imported into the United States, together with plants grown from cuttings brought into this country at the pathological greenhouses, Bureau of Plant Industry, United States Department of Agriculture, Washington, D.C., were used for artificial-inoculation investigations from 1930 to 1932. The cutting stock of Viking currant tested in the experiments, both in Scotland and in the United States, came originally from two sources in Norway; most of the cuttings came from the Agricultural College, Ås, and a few cuttings from the Norway State Fruit Experiment Station, Hermansverk, Sogn. The American experiments herein described supplement those previously reported from Great Britain (*4*) in 1929, wherein the Viking currant showed itself to be immune when artificially inoculated with aeciospores of fresh, vigorous Scottish strains of *Cronartium ribicola* obtained from diseased *Pinus monticola* Dougl. and *P. strobus* L., collected at Peeblesshire, Scotland. It was a matter of considerable importance to determine whether the introduced plants would show immunity to white pine blister rust when exposed to American strains of *C. ribicola*.

The methods of inoculation as set forth in a previous publication (*3*) were rigorously applied in the tests under discussion. Only vigorous plants were used whose shoots bore leaves in all stages of leaf development from the embryonic to those fully mature. Shoots were chosen possessing leaves that were fully expanded but still tender. In no case were leaves that had been affected by mildew or other fungi included in the experiments. Uninfected *Ribes* plants that had been atomized with boiled tap water were inoculated by dusting the under side of the leaves with spores from heavy aecial infections on cankered pine. Throughout the investigation an abundance of bright orange-yellow aeciospore material was available as inoculum. In applying the spores a generous amount of inoculum was applied in order to insure a general distribution of spores and maximum infection. Inoculations with fresh urediniospores from *Ribes aureum* Pursh were included in one test (that of Apr. 9, 1930).

In the 1930 experiments, the first three tests were performed in a pathological greenhouse of the United States Department of Agriculture at Washington, D.C., on April 8, 9, and 11; the last test for that year was conducted on April 24. In the 1931 experiments the tests were performed in the same greenhouse on April 7 and 9 and on May 6 and 7. Species and varieties of *Ribes* known to be fully susceptible to blister rust were included in the investigations

as checks on the Viking currant and served to demonstrate the viability of the spore inoculum used. In 1930 the rust strains used in the investigation consisted of *Cronartium ribicola* procured from fresh cankers of eastern white pine (*Pinus strobus*) collected in Massachusetts in March and April. In 1931 rust strains were obtained from freshly collected white pine cankers from New Hampshire.[10] Both the 1930 and 1931 tests included the original 18 plants of Viking currant propagated and tested in Edinburgh (*4*) in 1929.

The 1932 experiments were conducted on May 17 and 19 in a pathological greenhouse of the Marsh Botanical Garden, Yale University, New Haven, Conn. For these experiments aeciospore inoculum was obtained from fresh cankers of *Pinus strobus* collected in Massachusetts in April.

RESULTS OF 1930 TESTS

The Viking variety was found to be immune to fresh, viable aeciospores of white pine blister rust (table 1) so far as the production of fertile uredinia or telia was concerned. Hypersensitive infection areas, consisting of flecks of necrotic tissue, formed on leaves that had just reached the stage of complete expansion and whose texture was still very soft and tender. The leaf in the immature, wrinkled, unexpanded stage was only slightly sensitive to the rust. Leaves that had matured and hardened did not show any flecks or infection of any sort. Careful scrutiny of all the Viking plants under experiment, at intervals during the summer and early autumn, did not reveal the presence of fertile or even abortive rust fruiting bodies on any of the inoculated leaves.

TABLE 1.—*Types of reaction of the Viking and other currants to inoculation with aeciospores of Cronartium ribicola, 1931 and 1932*

Year and variety or species	Plants inoculated	Leaves inoculated		Plants showing on their spore-producing leaves the indicated abundance of uredinia [1]					Plants of specified reaction type [1]		
		Total	Infected	Trace	Slight	Moderate	Heavy	Very heavy	Immune	Resistant	Susceptible
1930	*Number*	*Number*	*Percent*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Viking [2]	57	562	0						57	0	0
American Red Dutch [3]	[3] 2	19	100	0	0	2	0	0	0	0	2
Fay (Fay Prolific)	20	198	79	2	1	10	7	0	0	0	20
Ribes aureum	17	141	100	0	0	5	12	0	0	0	17
R. odoratum	1	14	100	0	0	0	1	0	0	0	1
1931											
Viking	39	284	0						39	0	0
American Red Dutch	[3] 2	23	100	0	0	2	0	0	0	0	2
Fay	11	141	98	1	0	10	0	0	0	0	11
R. aureum	5	38	92	0	0	3	2	0	0	0	5
R. odoratum	3	35	100	0	0	3	0	0	0	0	3
R. nigrum	3	18	100	0	0	3	0	0	0	0	3

[1] In previous published material (*3*) the writer has used the following symbols: Trace, =; slight, −; moderate, ±; heavy, +; very heavy, ++; immune, O; resistant, ◑; susceptible, ●.

[2] Fresh urediniospores of *Cronartium ribicola* from *Ribes aureum* were used to inoculate 3 of these Viking plants.

[3] See Summary, p. 12. In addition to these 2 plants, inoculated in 1930 and reinoculated in 1931, 20 plants (199 leaves) showed 100 per cent of infection in 1929.

[10] Secondary fungi found in these cankers, associated with the *Cronartium*, included *Phomopsis occulta* Trav., *P. pseudotsugae* Wilson (*P. strobi* Syd.), *Scoleconectria scolecospora* (Bref.) Seaver, and a species of *Myxosporium*.

The hypersensitive infection areas, or flecks, referred to above were macroscopically similar (*4*, *pls. XII*, *XIII*) to those observed in the Scottish experiments conducted in 1929 at the Royal Botanic Garden, Edinburgh. In Scotland it had been observed that these flecks of necrotic leaf tissue were associated with the deposition of a tanninlike substance in the intercellular spaces and were surrounded by hypertrophied palisade and spongy mesophyll tissue in which the chloroplasts had disappeared.

On the susceptible check plants normal infection was plainly discernible within 8 days after inoculation, and yellow urediniospores began to appear 2 days later (table 1). The checks included two varieties, Fay (Fay Prolific) and the American Red Dutch of the *macrocarpum* section of the *Ribes sativum* group (*8*, *fig. 2* and *pl. 1*, *A*), the golden currant (*R. aureum*), and the closely related *R. odoratum* Wendl. f.

It is interesting to note that in the case of the susceptible check plants of hybrid varieties of *Ribes sativum* just mentioned the inoculation of the very tiny, tightly folded embryonic leaves at the tips of the shoots did not result in infection. Leaves at about the stage of complete expansion showed only a slight occurrence of the rust. Uredinia in this instance were associated with a necrotic condition of the tissue about the pustules, thereby indicating a resistance to infection at this stage of leaf development. The leaves at the base of the shoot, in cases where tissue had fully matured and had become senescent, showed a reduced number of fertile uredinia. The completely expanded but unhardened leaf surface between the two points just described (fig. 2) showed a moderate to abundant production of normal uredinia. This resistance of the youngest and oldest *Ribes* leaves to infection was demonstrated by Spaulding and his associates (*6*). Under greenhouse conditions at Washington, where high spring temperatures are encountered, the infected leaf tissue about the rust pustules died quickly. The uredinia in turn became brownish and degenerate, and the infected leaves, decolorized and partly shriveled, readily separated from the shoot.

RESULTS OF 1931 TESTS

The necrotic flecks that formed when the blades of the leaves of the Viking currant were reaching full expansion were observed again in the tests of the third year. These flecks occurred as a trace, scantily, or moderately on the young folded leaves or on those fully expanded below the tiny unfolded leaves at the tip of the shoot; in leaves in which the tissue was fully mature these necrotic flecks did not occur at all. Flecks were never observed on inoculated embryonic leaves at the apex that were very minute and tightly folded at the time of testing. As in the 1930 tests, fertile or abortive uredinia or telia did not form on any of the tested leaves (table 1). It is important to note that the immunity of the original 18 plants which were first reported in 1929 (*4*) as resistant to strains of Scottish white pine blister rust and which were subsequently found to be immune when exposed to American strains of blister rust, was demonstrated for a period of 3 years.

The susceptible check plants tested along with the Viking currant included the same *Ribes* species and varieties of red currant as were

incorporated in the 1930 experiments.[11] Three plants of *Ribes nigrum* L. that had been propagated at the pathological greenhouses from cuttings collected by A. E. Fivaz at Tupper Lake, N.Y., were also included. In the first two tests the susceptible plants showed fertile uredinia and only a trace of telia. This also applied to the last two tests. As shown in table 1, the plants of *Ribes nigrum* from Tupper Lake became infected only moderately with the rust, despite the fact that black currant is very highly susceptible to blister rust. Continued investigation may possibly demonstrate that in the case of this particular *R. nigrum* (which is apparently a case of reversion to the wild) we may be dealing with strains among the Tupper Lake population that may vary with respect to susceptibility. Spaulding and his associates (*6*) have shown that certain varieties of *R. nigrum* appeared to vary greatly in susceptibility.

In the April inoculation tests, as in the experiments of the preceding year, leaves of the susceptible variety Fay did not show fertile infection upon the minute, tightly folded, apical leaves (fig. 2). In the May experiments, however, the experimental plants of this variety that had been standing in the greenhouse since the first two tests possessed apical leaves fully expanded but still very tender and soft. As might be expected, optimum rust infection was obtained upon these tender leaves at the shoot tip; the leaves below, which were fully mature and hardened, showed only a few fertile uredinia or were not infected at all.

RESULTS OF 1932 TESTS

In the spring of 1932 approximately 1,000 Viking currants propagated from cutting stock procured in 1930 from Ås, Norway, were sent out from Washington for field testing in New England, New York, Oregon, and Canada. These plants were planted in areas infested with blister rust, where the introduced currant would be subjected to natural infection. This experiment is to be carried on for 3 years (1932 to 1934). At this time the writer is able to report that in not a single instance did any of the field-planted currants become infected in 1932 or 1933, although blister-rust spores were generally abundant and conditions in certain instances were optimum for natural infection. The Viking proved to be immune to both eastern and western strains of *Cronartium ribicola*. In Canada the introduced currant was planted along with the very susceptible European black currant. The former remained immune, whereas the black currant check plants were heavily infected.

Of the small number of Viking currants brought to the pathological greenhouse at New Haven, 7 plants were inoculated on May 17 and 19 with freshly collected aeciospores from Massachusetts. This number included 5 of the 18 Viking plants originally inoculated in Scotland in 1929. In all, 113 leaves, which included all stages of

[11] The April tests in 1931 were supplemented by the inoculation of 10 young plants of a *Grossularia* hybrid (no. 3036), originated by Frederick V. Coville, between an American variety of gooseberry named Carrie, which originated as a hybrid between *Grossularia reclinata* (L.) Mill. and *G. hirtella* (Michx.) Spach, and the Florida gooseberry, *G. echinella* Coville, discovered in northern Florida by the author of the last-named species. All showed moderate infection by the rust, and in certain plants a few leaves became heavily infected. A month after inoculation, telia were observed among the fertile uredinia on all the plants except one; these were to be found on all except the very youngest leaves at the tip. Petiolar infection was common. Since both parents of the hybrid were known to be readily susceptible to the rust, the fact that the hybrid also showed susceptibility was not surprising. The inclusion of the *Grossularia* hybrid in the 1931 tests served as an additional check in demonstrating the vigor of the inoculum used.

development, were tested. In no case did either fertile or aborted uredinia or telia form. As in the preceding experiments, necrotic flecks were observed to form upon the expanding leaves at the tips of the shoots.

FIGURE 2.—Shoot of Fay currant, belonging to the *macrocarpum* section of the hybrid *Ribes sativum* group. Heaviest infection was found just back of the tip. When the entire shoot was inoculated, the two apical leaves were very minute and tightly folded. They did not become infected. (About one-half natural size.)

In these experiments the different stages of leaf development were marked by silk threads. The tightly folded bud leaves at the shoot tips, when dusted with aeciospores, did not show sensitive infection areas. To make certain of this, careful scrutiny was maintained over them during their development after the inoculation. Leaves that were further advanced but immature and folded at the time

of the inoculation developed only a trace of flecks along the periphery of the leaf or occasionally near the midrib, whereas those that were completely expanded but still very soft and tender showed necrotic flecks distributed over the entire leaf surface. Leaves that were fully mature showed no signs of infection. *Grossularia cynosbati* (L.) Mill., which was used as a check plant, readily became infected.

SUMMARY OF TESTS

During the 4-year period of greenhouse experimentation (1929 to 1932), in which strains of *Cronartium ribicola* from both Great Britain and the United States were tested, the Viking currant showed itself to be consistently immune so far as the production of uredinia or telia of any sort was concerned. Of 1,140 leaves inoculated (*4, table 1;* table 1 in text, p. 8), none produced either fertile or abortive fruiting bodies of the rust. The tests involved all stages of leaf development. In choosing hosts for experimental purposes, plants with leaves fully expanded but still tender were preferred, for it was at this developmental stage of leaf tissue that rust infection on *Ribes* ordinarily occurred. The total number of Viking plants tested (*4, table 1;* table 1 in text, p. 8) included a triplicate set of 18 plants tested successively over the 3-year period, 5 of which were tested for the fourth time in 1932. There was also a duplicate set of 12 plants tested from 1930 to 1931. The present report gives the results of 4 years of artificial tests on 66 individual plants derived from cuttings from both Ås and Hermansverk, Norway.

Checks, including a total of 22 plants (241 leaves) of the American Red Dutch (*4, table 1;* table 1 in text, p. 8), readily became infected with *C. ribicola*, thereby demonstrating the ability of the inoculum used to germinate and infect susceptible *Ribes* hosts. The American Red Dutch (pl. 1, *A*) tested in the foregoing experiments was obtained from P. Stedje, Hermansverk, Norway, who had originally procured the stock from Paul Thayer in Ohio.

INOCULATION EXPERIMENTS WITH PIÑON BLISTER RUST

In a consideration of the Viking currant as a garden variety to be used horticulturally in the control program of blister rust in the Pacific Northwest, the question presented itself as to the immunity of the introduced variety to *Cronartium occidentale* Hedgc., Beth., and Hunt. This blister rust of piñon pine, though of little economic importance, complicates the pathological picture in the Pacific Northwest, because the native rust of the nut pine is very closely related to the introduced blister rust of the white pine. The morphological similarity of the rusts in the uredinial stage on *Ribes* is so very close that macroscopically they cannot be differentiated (*5, p. 105*). Accordingly, the determination of the reaction of the Viking currant to *C. occidentale* was an important point that needed to be solved, particularly in view of the possible introduction of the currant later into the West as a part of the control program.

Greenhouse inoculation tests were made with inoculum consisting of fresh aeciospores from blister cankers of *Cronartium occidentale* collected on May 18, 1931, on *Pinus monophylla* Torrey and Fremont, Carters Station, Nev., at an elevation of 6,000 feet. As checks on

this experiment, for the purpose of establishing the viability of the inoculum, the rust-susceptible hosts, *Ribes aureum* and *R. nigrum* from Tupper Lake, were inoculated in parallel series. Plants of the variety Fay were also included among the checks. This red currant, which previous investigation has shown to be a good differential host in separating physiologically the two blister rusts (*5*), was inoculated with both the white pine blister rust and the native piñon rust.

Results of the inoculation experiments with *Cronartium occidentale* are shown in table 2. Although this test was limited, the results are significant. It would have been a very unusual occurrence indeed for the Viking currant to show susceptibility to piñon rust; for red and white currants that have been tested (*5*) have usually proved to be immune to the native organism. In no case were fertile uredinia or telia or abortive fruiting bodies observed on the inoculated leaves of the Norwegian currant. As in the case of the tests made with aeciospores of white pine blister rust, necrotic flecks appeared in amounts ranging from a trace to a moderate number on the tender leaves just below the minute, tightly folded leaves at the apex of the shoot. These flecks were macroscopically similar to those associated with white pine blister rust. In no case did the tightly folded bud leaves as they developed show signs of flecking, nor did the fully matured leaves at the base of the shoot.

TABLE 2.—*Types of reaction of the Viking and other currants to inoculation with aeciospores of Cronartium occidentale and C. ribicola, 1931*

Variety or species	Plants inoculated	Leaves inoculated		Plants showing on their spore-producing leaves the indicated abundance of uredinia [1]					Plants of specified reaction type [1]		
		Total	Infected	Trace	Slight	Moderate	Heavy	Very heavy	Immune	Resistant	Susceptible
	Number	*Number*	*Percent*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
REACTION TO CRONARTIUM OCCIDENTALE											
Viking	11	74	0						11	0	0
Fay (Fay Prolific)	3	46	0						3	0	0
Ribes aureum	6	36	100	0	0	4	2	0	0	0	6
R. nigrum (Tupper Lake)	2	16	25	2	0	0	0	0	0	0	2
REACTION TO CRONARTIUM RIBICOLA											
Fay	2	26	73	0	1	1	0	0	0	0	2
R. aureum	3	18	100	0	0	3	0	0	0	0	3

[1] See footnote 1, table 1.

A moderate to heavy rust infection, producing 50 percent of telia within a month on the inoculated leaves of *Ribes aureum*, gave ample proof of the viability of the spores of the piñon rust used for inoculum. *Cronartium occidentale* produced only a trace of uredinia and telia on the two plants of *R. nigrum* from Tupper Lake. (See results with *C. ribicola* in table 1.) Infection, as has been previously shown for piñon rust on varieties of this *Ribes* species (*5*), occurred only on the older leaves at the base of the shoot. Plants of the Fay variety of red currant in excellent leaf condition did not produce fertile or abortive uredinia or telia. Necrotic flecks formed

in the tissue of tender, completely expanded leaves of this *R. sativum* hybrid, just behind the tip of the shoot. In a separate parallel test, in which the variety Fay was inoculated 2 days later with *C. ribicola* instead of with *C. occidentale* (table 2), fertile uredinia appeared in place of the necrotic flecks produced by the piñon rust. These results obtained with the variety Fay corroborate results of former tests (*5*), which demonstrated both its immunity to *C. occidentale* and its susceptibility to *C. ribicola.*

DISCUSSION

The varieties of the cultivated red and white currants show considerable variation in the degree of their susceptibility to white pine blister rust. Some varieties are very congenial hosts for the rust, abundant uredinia and telia being produced. In other varieties the leaf tissue dies before many telia are formed. In other cases only a few uredinia form, associated with irregular areas of leaf tissue which die quickly and which may or may not be accompanied by a spread of the fungus. In cases of extreme resistance only small flecks of tissue are killed. These flecks may produce a very small number of uredinia or telia, or, as in the case of the immune Viking variety described in this paper, they may die quickly without producing fruiting bodies of any sort. The leaves of the Viking currant are sensitive to the spores of blister rust for only a limited period in their development; when the leaves have matured and have ceased to be tender they become impervious to the disease.

Varieties of red currant obtained from nurserymen have been reported as immune or highly resistant (very slightly infected) by Spaulding (*6, p. 17–23*) and the writer (*5*). Because of the limited number of tests made, these published results of varieties apparently immune cannot be accepted unqualifiedly. Moreover, it happens frequently that the stock of a given varietal name from one nursery may not be the same as that of the same name from another nursery. Actual tests must be made to determine whether the true immune or highly resistant variety is being dealt with.

The results of artificial inoculation tests with the Viking currant presented in this paper would seem to indicate that probably in this particular instance we are dealing with a variety [12] unquestionably immune to white pine blister rust, and Tubeuf [13] (*10, pp. 439, 458–460*) has recently reported similar results with a variety of cultivated red currant, Rote Holländische, which in his opinion is likewise really immune to the disease. As has been pointed out, the Viking currant is a *Ribes petraeum* hybrid, showing the characters of that species strongly. It is closely related to the varieties Holland and Prince Albert, both regarded by Thayer (*8*) as either pure *R. petraeum* or hybrids of that species.

As previously mentioned, *Ribes petraeum* is a native of the high mountains of Europe and northern Africa and of most of Siberia.

[12] This currant was brought to the writer's attention by Ivar Jørstad while making forest pathological observations in Norway in 1927.

[13] The Red Dutch variety (Rote Holländische Johannisbeere) reported by Tubeuf (*9, 10*) as being consistently immune to white pine blister rust in Germany is nearly related to the variety Prince Albert. Tubeuf (*10, p. 460*) citing Berger (*1*) regards the Rote Holländische as a synonym of Prince Albert, a hybrid closely resembling *Ribes petraeum.* However, we do not know whether the immune variety reported by Tubeuf is identical with the Viking currant from Norway or not. There may be a close relationship between the two. Tubeuf (*10*) states that the seed of the test plants, investigated 1928 to 1932, did not germinate.

Thayer (*8*) describes the species as producing bushes with stiff, erect shoots, late in starting in the spring, holding the foliage in autumn, and resistant to the attack of the currant worm. He states (*8, p. 319*) that Janczewski names six different types under *R. petraeum*, designating *R. petraeum bullatum* (Otto and Dietr.) C. Schneid. as probably the one from which cultivated currants of this species were derived.

Both Spaulding and his associates (*6, 7*) and the writer (*5*), in experimental tests with *Ribes petraeum*, found that species to be susceptible to white pine blister rust. Spaulding (*6*) reported the *R. petraeum* varieties Holland (synonym Franco-German) and Rivers Late Red as resistant but not absolutely immune. The writer (*5*) independently investigating Holland and Franco-German nursery stock obtained from other sources, observed these varieties, regarded by Thayer as identical, to be immune but in a very limited number of tests. Both Spaulding (*6*) and the writer (*5*) observed a slight infection of the *R. petraeum* variety Prince Albert. Rust resistance possibly may be a dominant character, originating by crossing and expressed by certain cultivated hybrids of the *R. petraeum* group.

The importance of a red currant immune to white pine blister rust and desirable horticulturally is apparent. As Spaulding and Gravatt (*7*) and Tubeuf (*9, p. 27*) have pointed out, a cultivated currant or gooseberry not susceptible to the disease and possessing commercial qualities would be of much practical importance for future planting within the diseased areas.

On the other hand, for horticultural areas where the growing of white pine is not an economic factor, the Viking holds promise as a valuable disease-resistant variety to replace the susceptible varieties now being grown. There is every reason to expect that it will be found suited to the currant-growing districts of the country. Should the Viking show the same resistance to heat and drought as the two nearly related varieties Holland and Prince Albert, it will be especially suitable for cultivation in the Prairie States. The Viking currant should also be of value as breeding stock for crossing with desirable American varieties known to possess rust resistance.

SUMMARY

A red currant variety from Norway, herein described under the new name "Viking", has been found to be immune to white pine blister rust under conditions of artificial greenhouse testing over a period of 4 years. The variety, which was apparently introduced into the United States for the first time during the present investigation, seems to belong to *Ribes petraeum*, and has been cultivated many years in Norway, where it is regarded by pathologists as highly resistant to Norwegian strains of blister rust. A preliminary description is given, together with comparative leaf characters of other varieties.

The Viking currant was first tested under greenhouse conditions in Scotland, in 1929, with aeciospores of British strains of *Cronartium ribicola* from *Pinus monticola* and *P. strobus*, and was found to be immune. The stock tested came from two localities in Norway, namely, Hermansverk, Sogn, and Ås.

Subsequent greenhouse tests, from 1930 to 1932, in the United States, with aeciospores and urediniospores of American strains of *Cronartium ribicola* from *Pinus strobus*, further demonstrated the immunity of plants of the Viking stock originally tested in Scotland and additional material from Ås. In no case during the 4 years' experimentation in the greenhouse did fertile or abortive uredinia or telia develop. Necrotic flecks formed in expanded leaves that were tender and unhardened. The fully mature leaves did not show any sign of infection. Susceptible check plants, used in the experiments to demonstrate the viability of the inoculum, readily became infected.

The Viking currant has been found to be immune to aeciospores of the native piñon blister rust (*Cronartium occidentale*) on *Pinus monophylla*.

Field tests of the immunity of the Viking currant to *Cronartium ribicola* were instituted in 1932. The variety was placed in close proximity to diseased pine in New England, New York, Oregon, and Canada. Approximately 1,000 plants have been set out, none of which showed infection during 1932 and 1933. Susceptible check plants set out with the introduced variety were in many instances heavily infected.

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